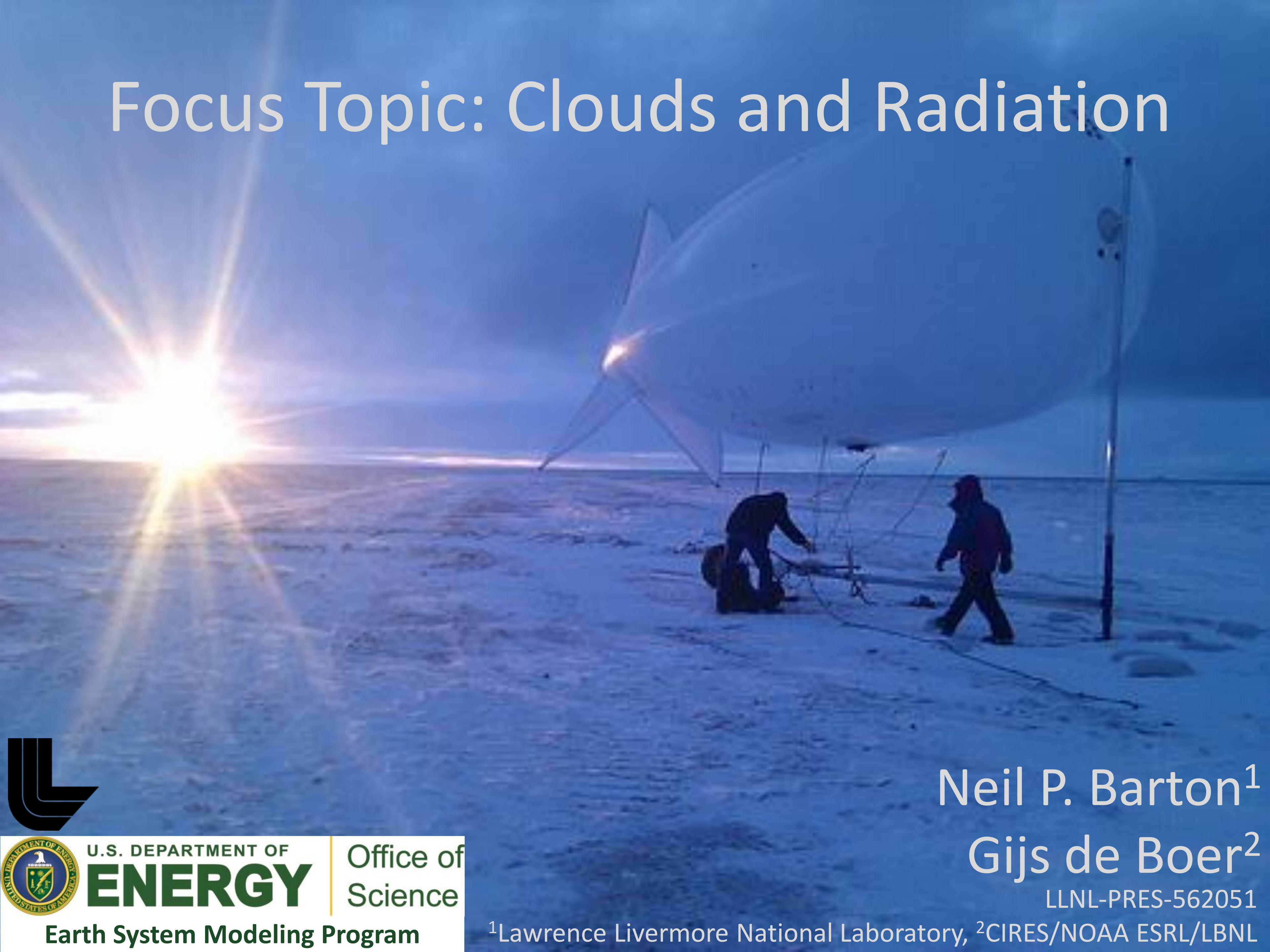


Focus Topic: Clouds and Radiation

Neil P. Barton[1]
Gijs de Boer[2]

LLNL-PRES-562051

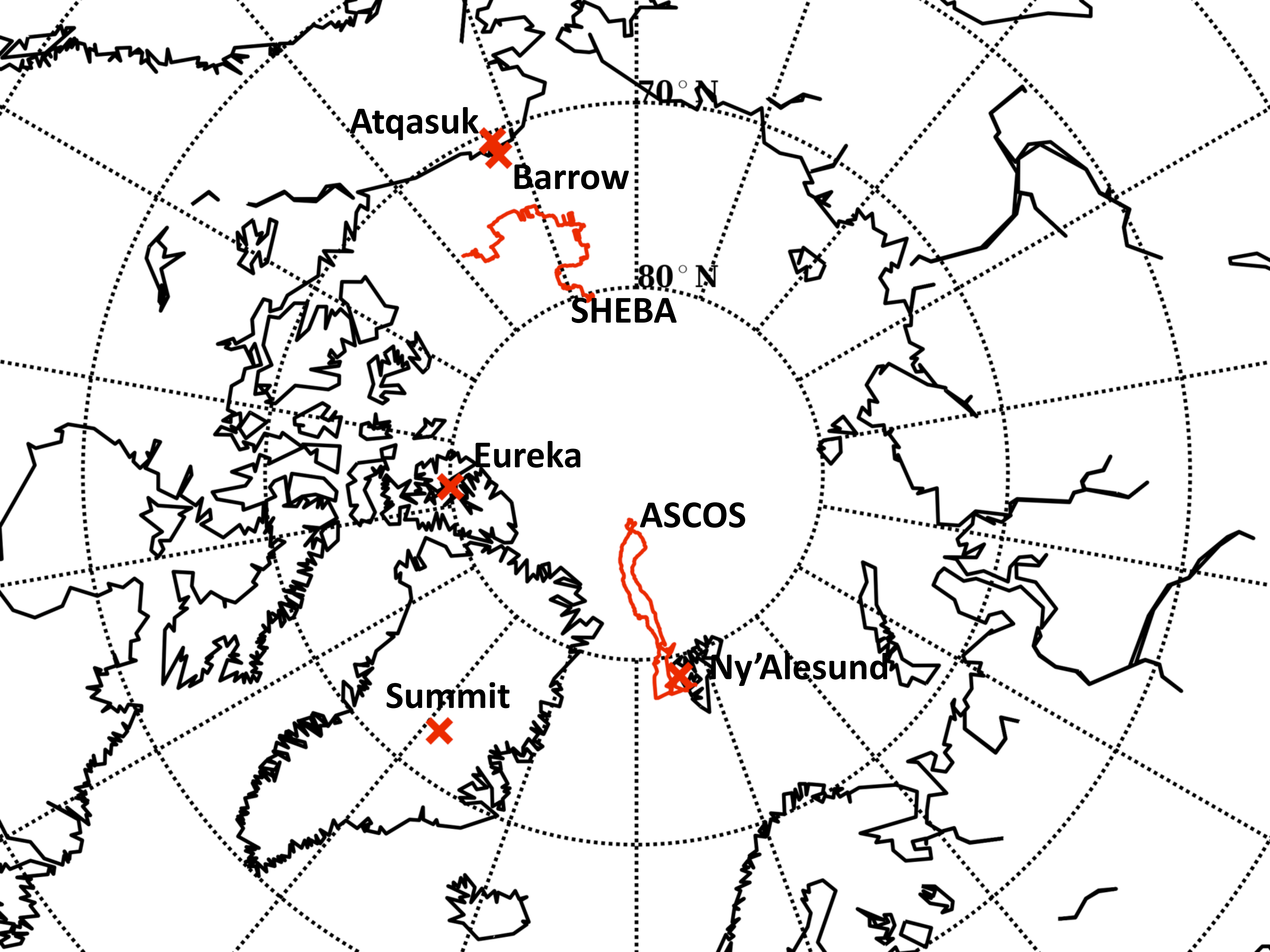
[1]Lawrence Livermore National Laboratory, [2]CIRES/NOAA ESRL/LBNL

U.S. DEPARTMENT OF ENERGY | Office of Science

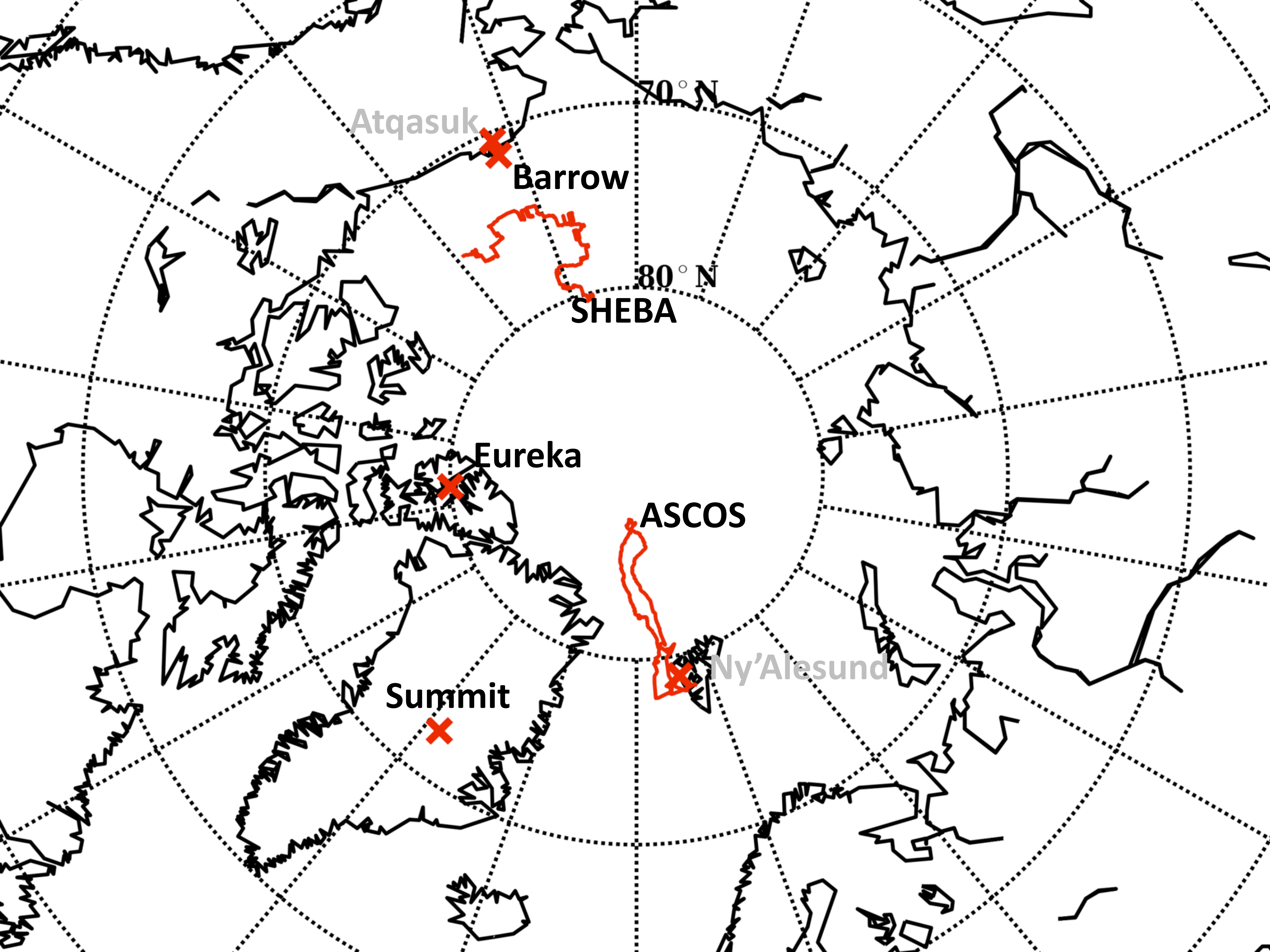
Earth System Modeling Program

Outline

- Data Availability/ Overview of Current Research
  - Surface Data
  - Satellite Data
- Possible Research Directions
- Observations Needed for Models
- Discussion Points



70° N
80° N
Atqasuk
Barrow
SHEBA
Eureka
ASCOS
Ny'Alesund
Summit



70° N
80° N
Atqasuk
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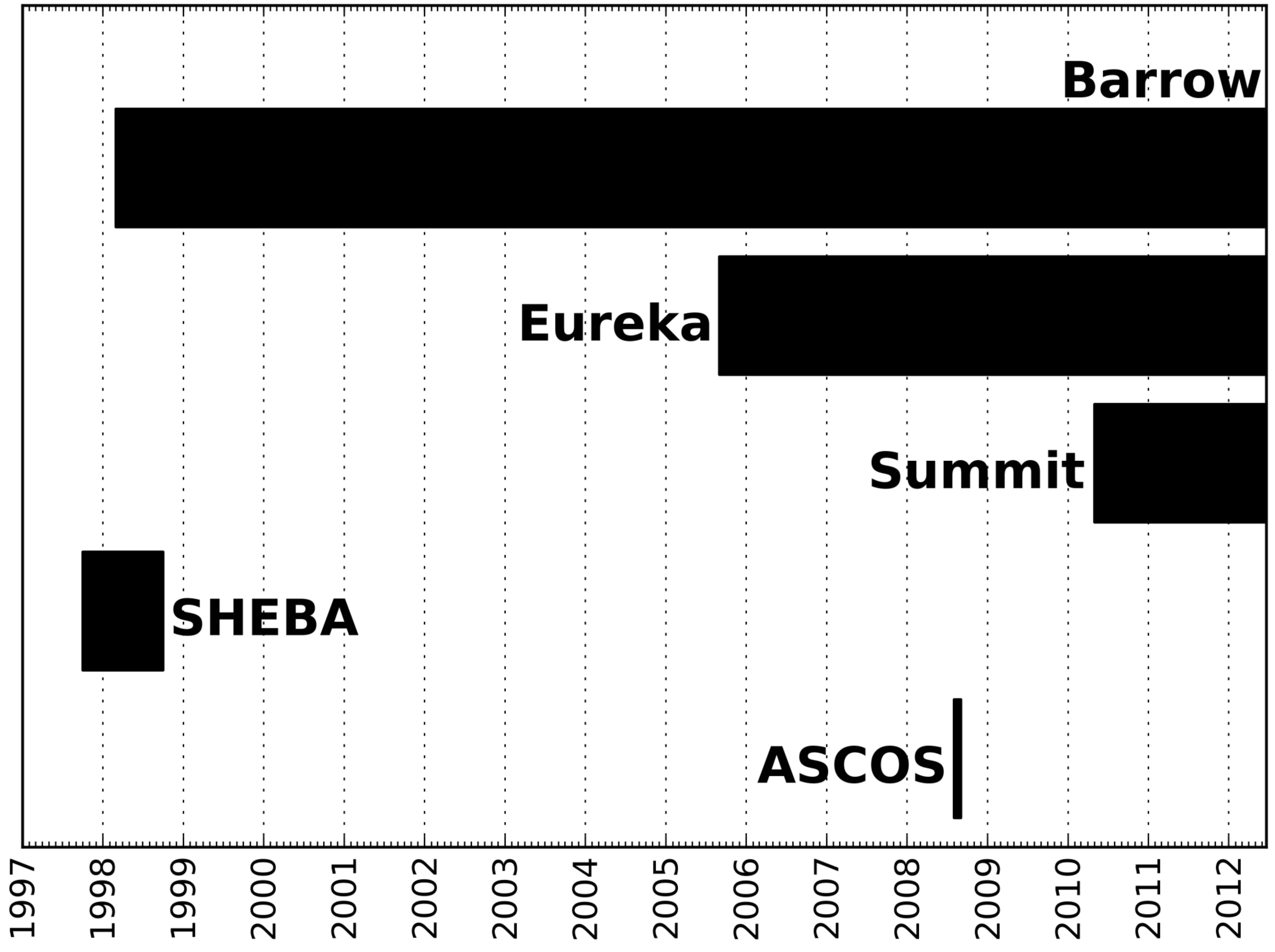
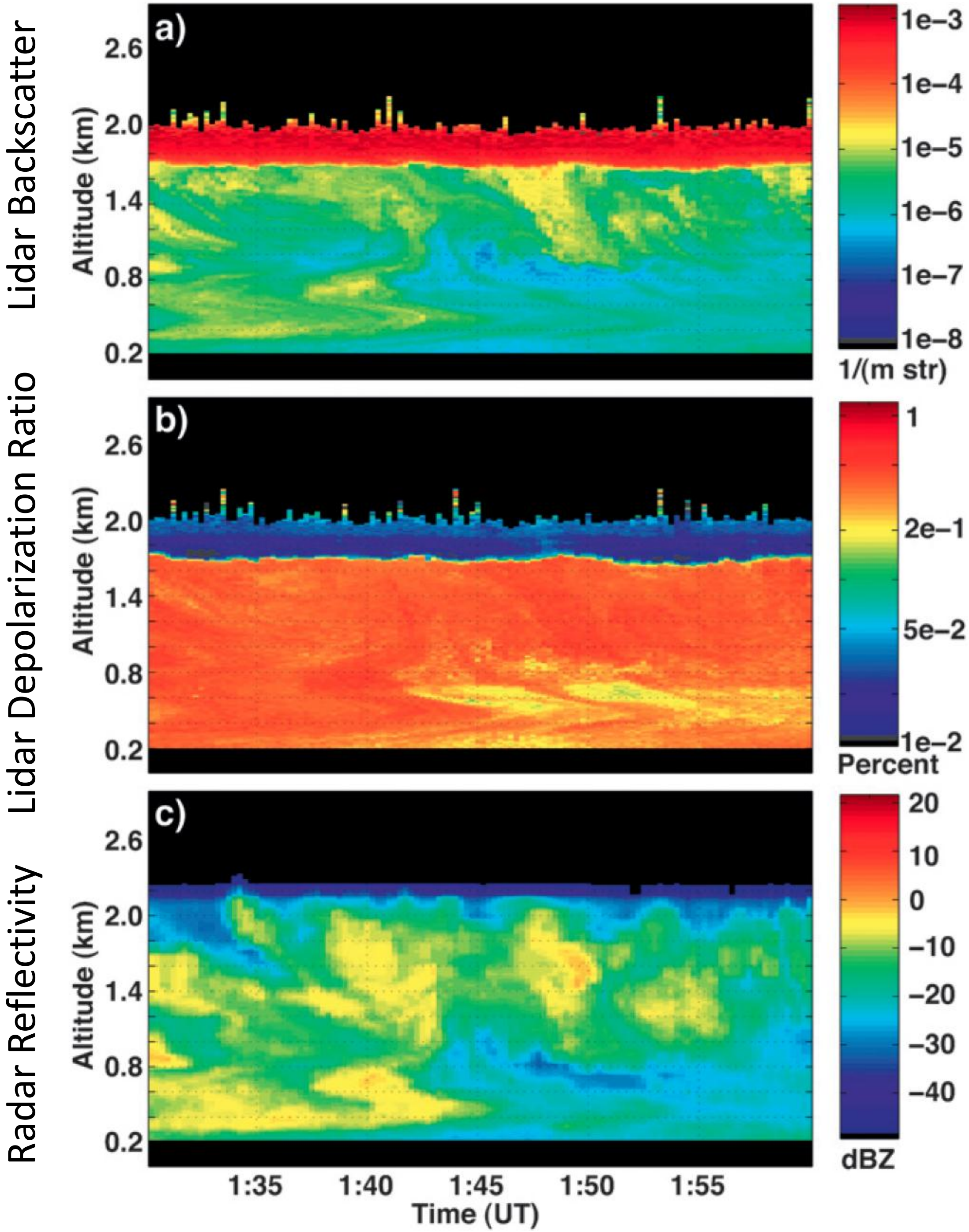
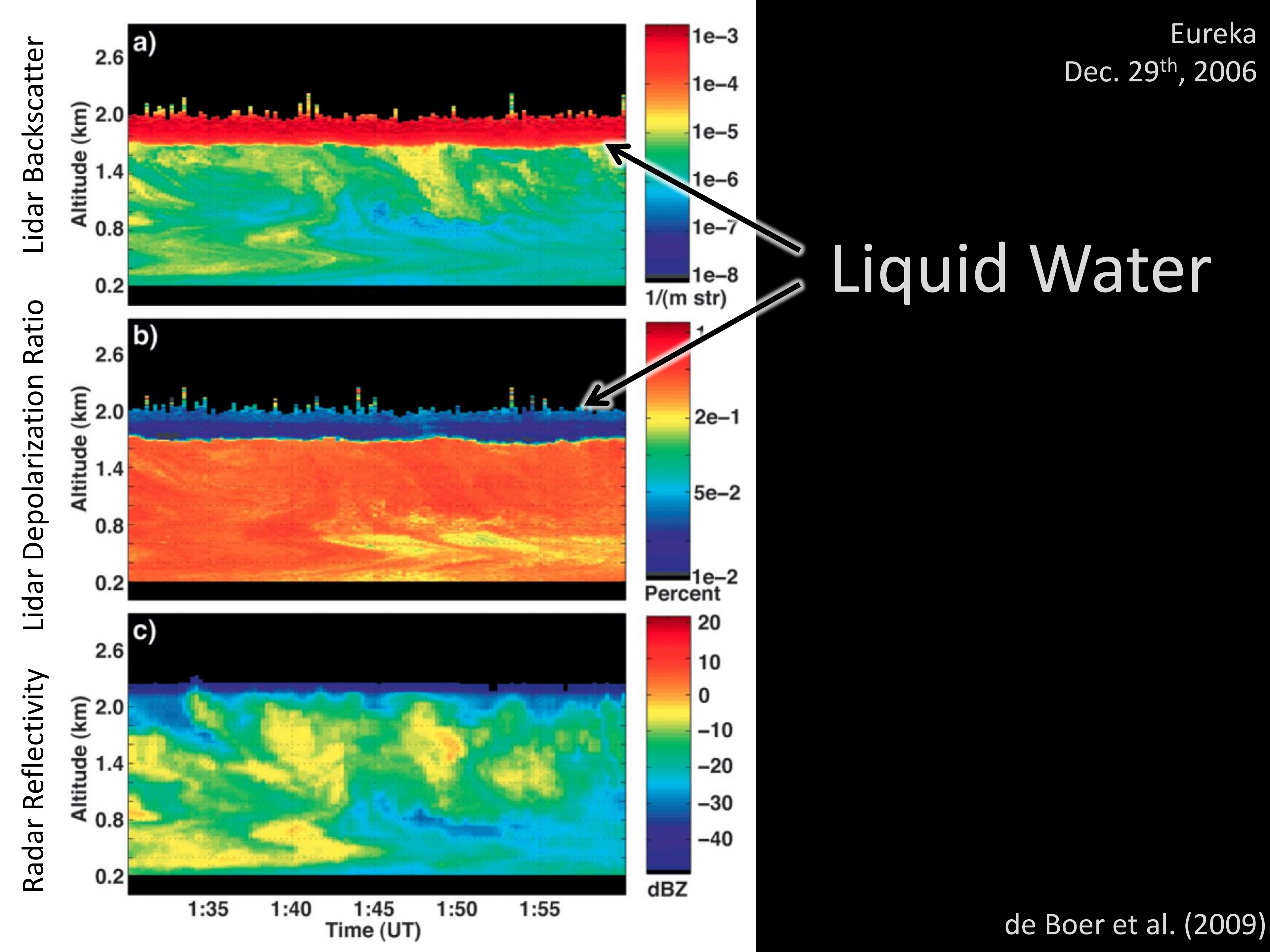


Barrow
Eureka
Summit
SHEBA
ASCOS
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

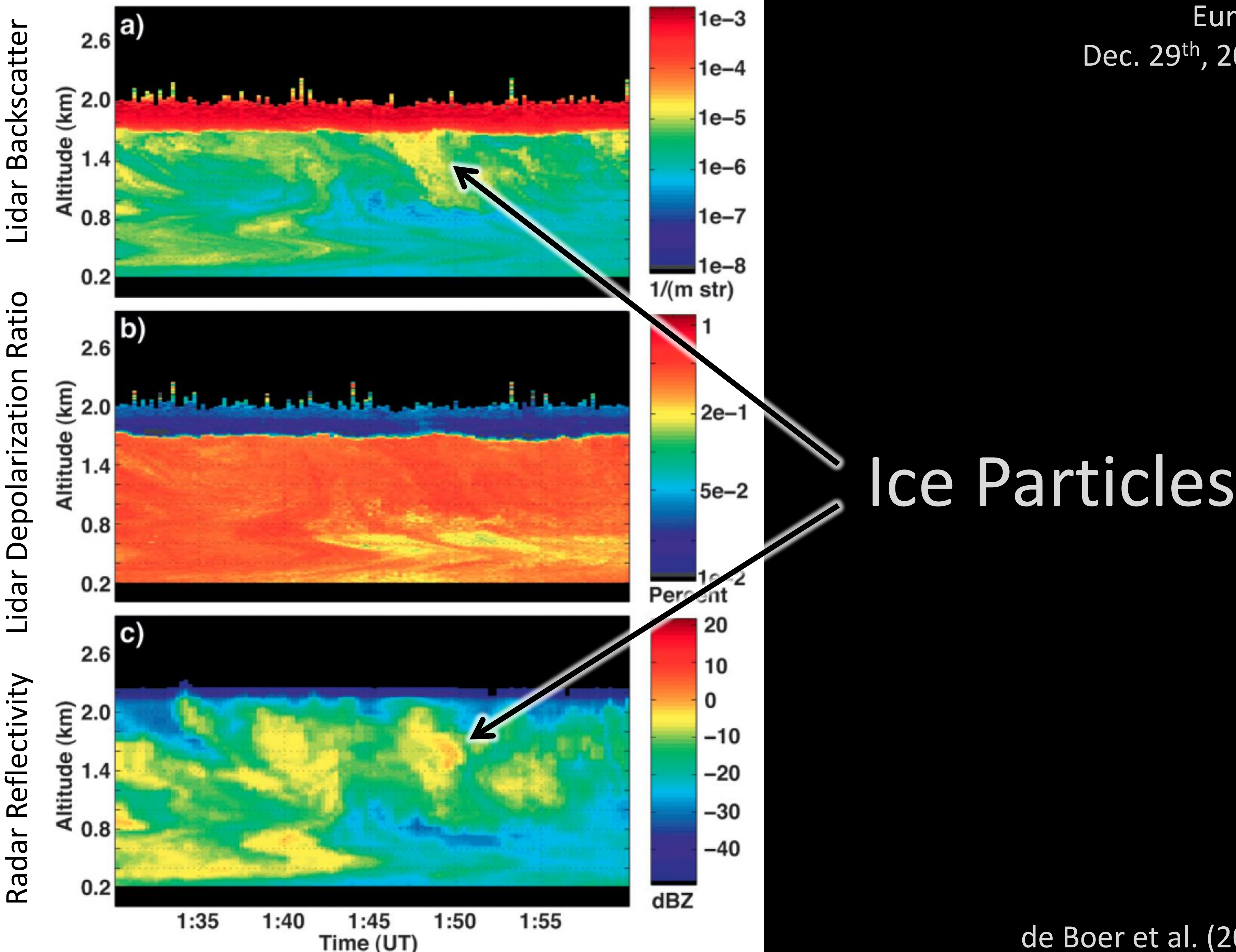
Eureka
Dec. 29th, 2006



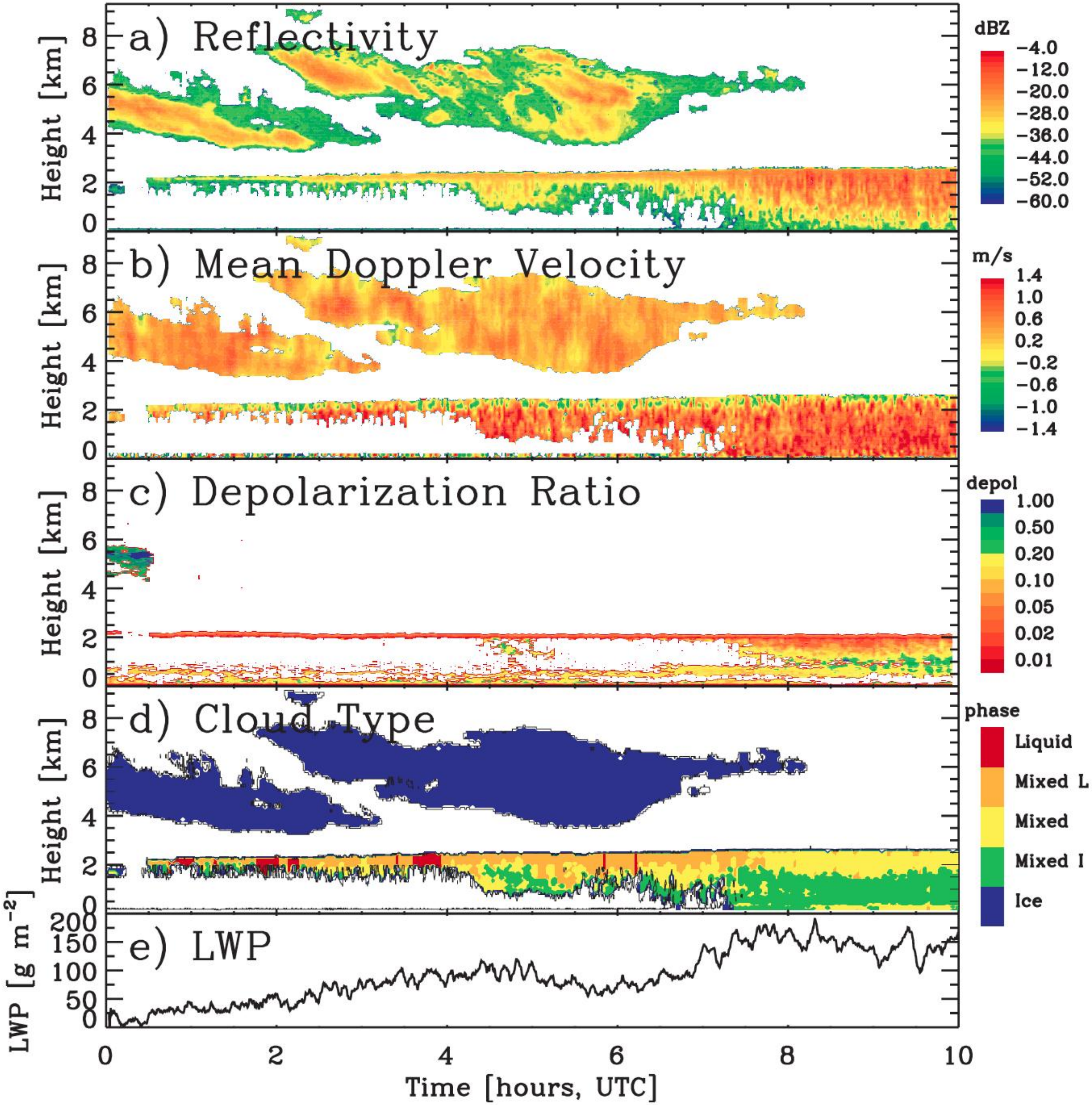
de Boer et al. (2009)


Eureka
Dec. 29th, 2006
Liquid Water
Lidar Backscatter
Lidar Depolarization Ratio
Radar Reflectivity
a)
b)
c)
Altitude (km)
2.6
2.0
1.4
0.8
0.2
1e−3
1e−4
1e−5
1e−6
1e−7
1e−8
1/(m str)
1
2e−1
5e−2
1e−2
Percent
20
10
0
−10
−20
−30
−40
dBZ
1:35
1:40
1:45
1:50
1:55
Time (UT)
de Boer et al. (2009)

Eureka
Dec. 29th, 2006



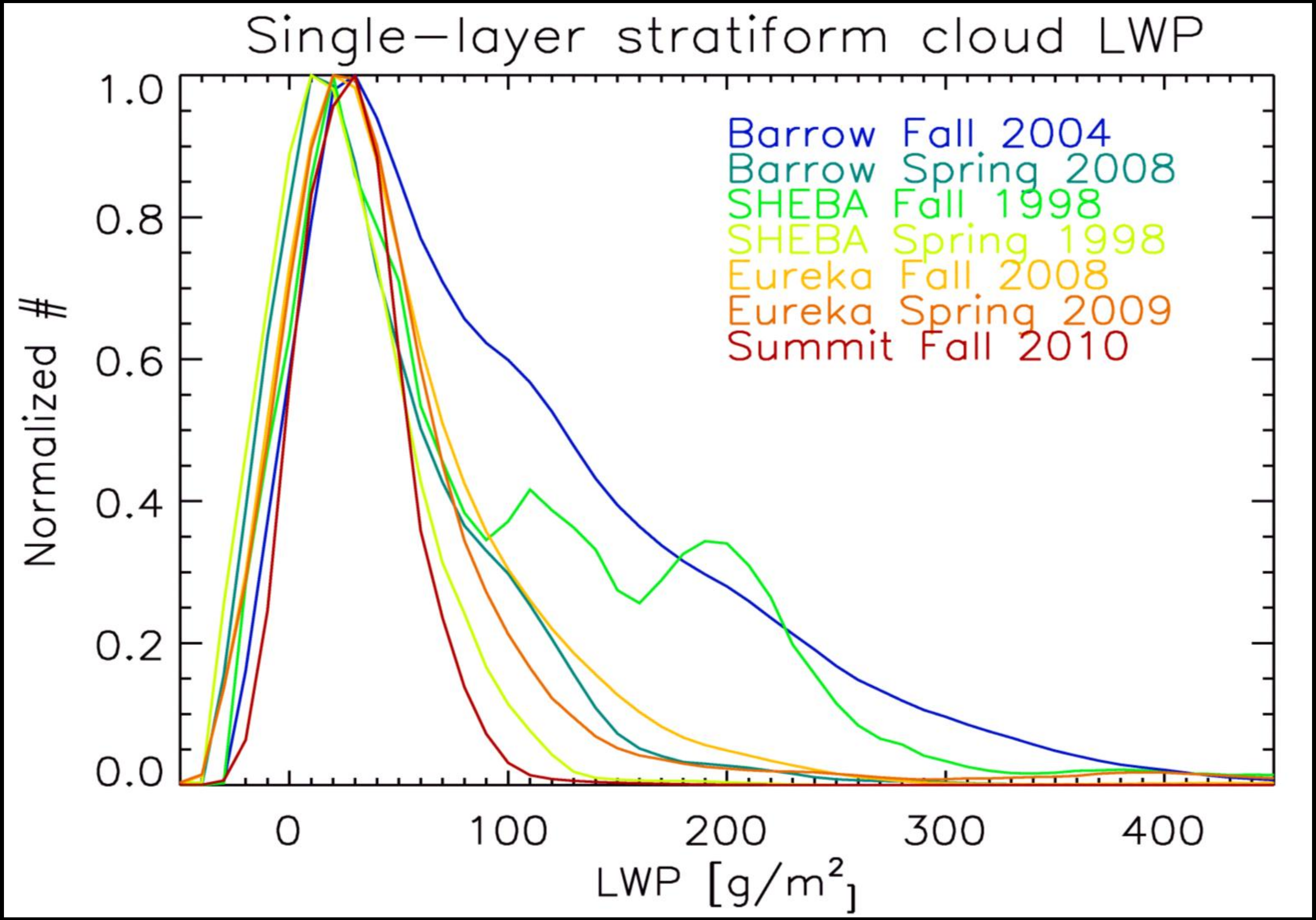
de Boer et al. (2009)



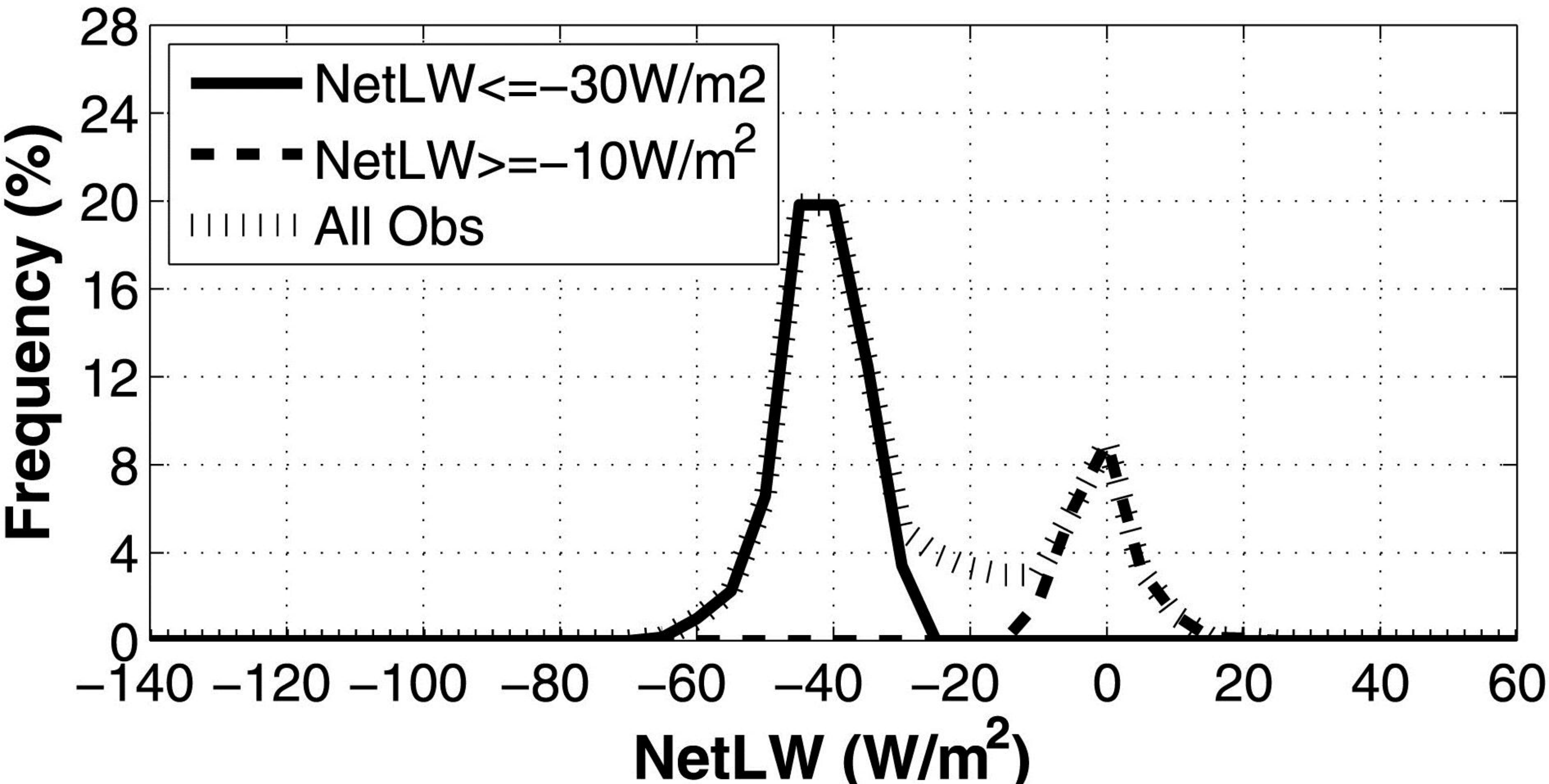
Eureka
Sept. 21th, 2008

Shupe (2011)

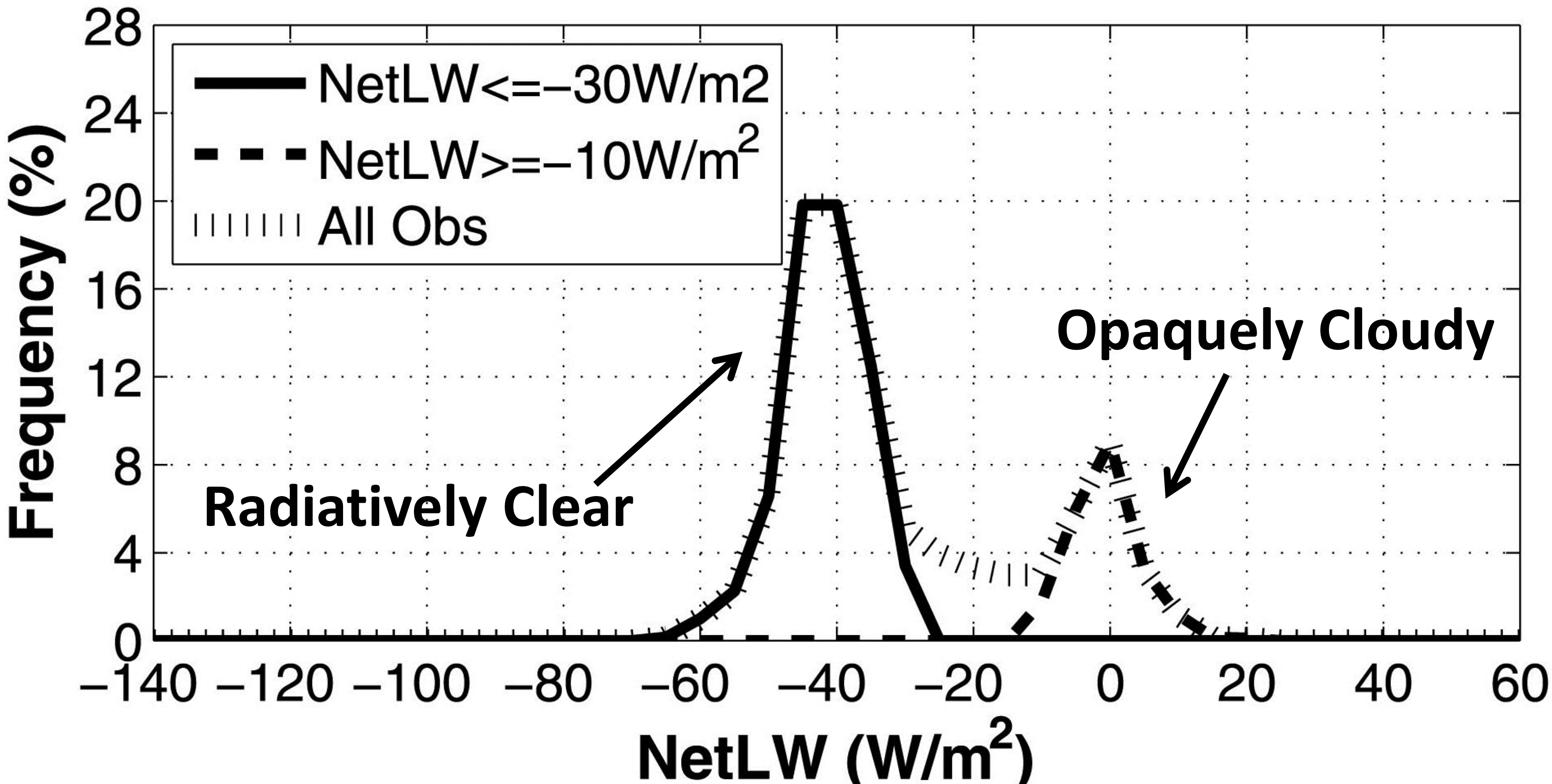
Low Cloud Liquid Water Amount



from Matthew Shupe

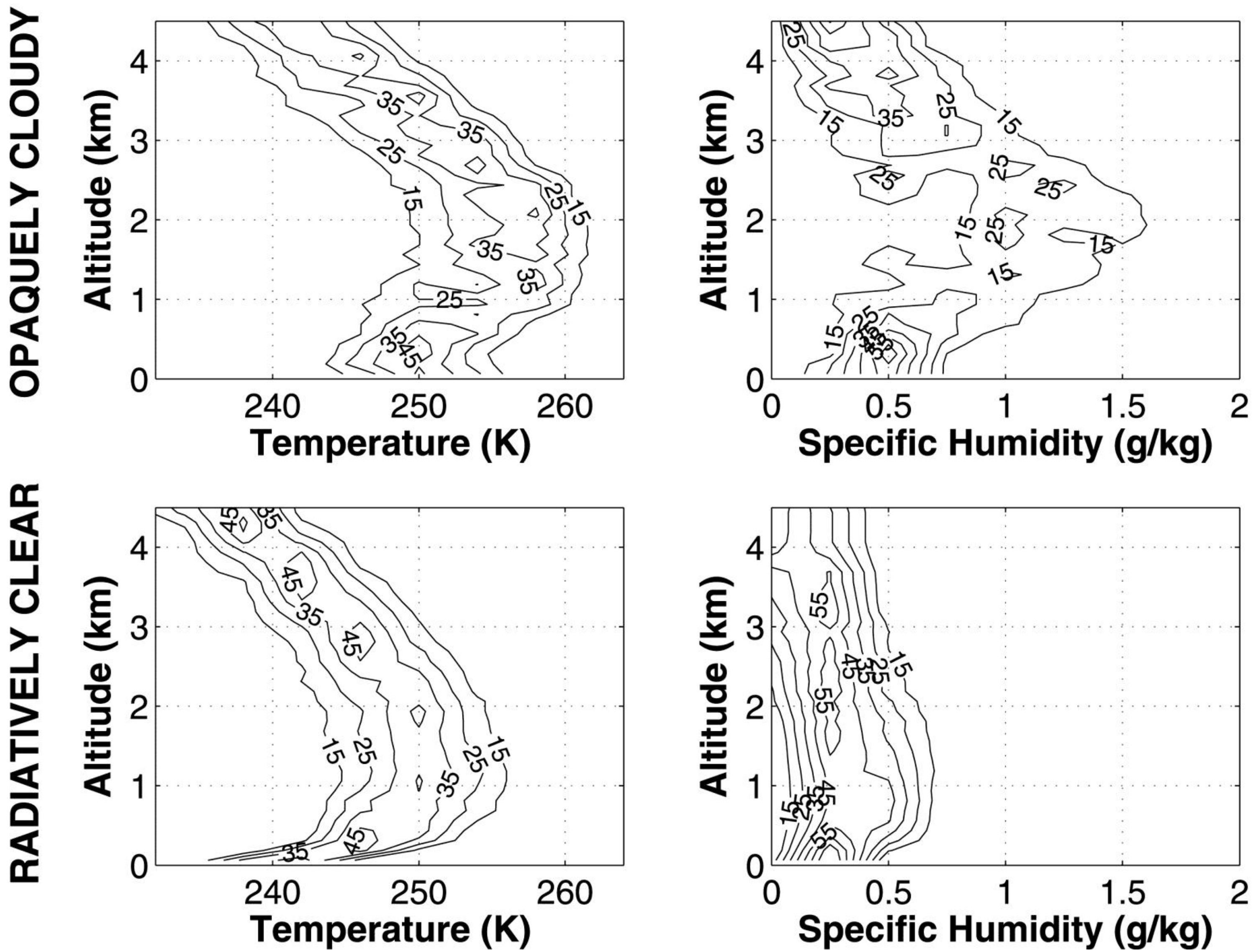


Stramler et al. (2011)

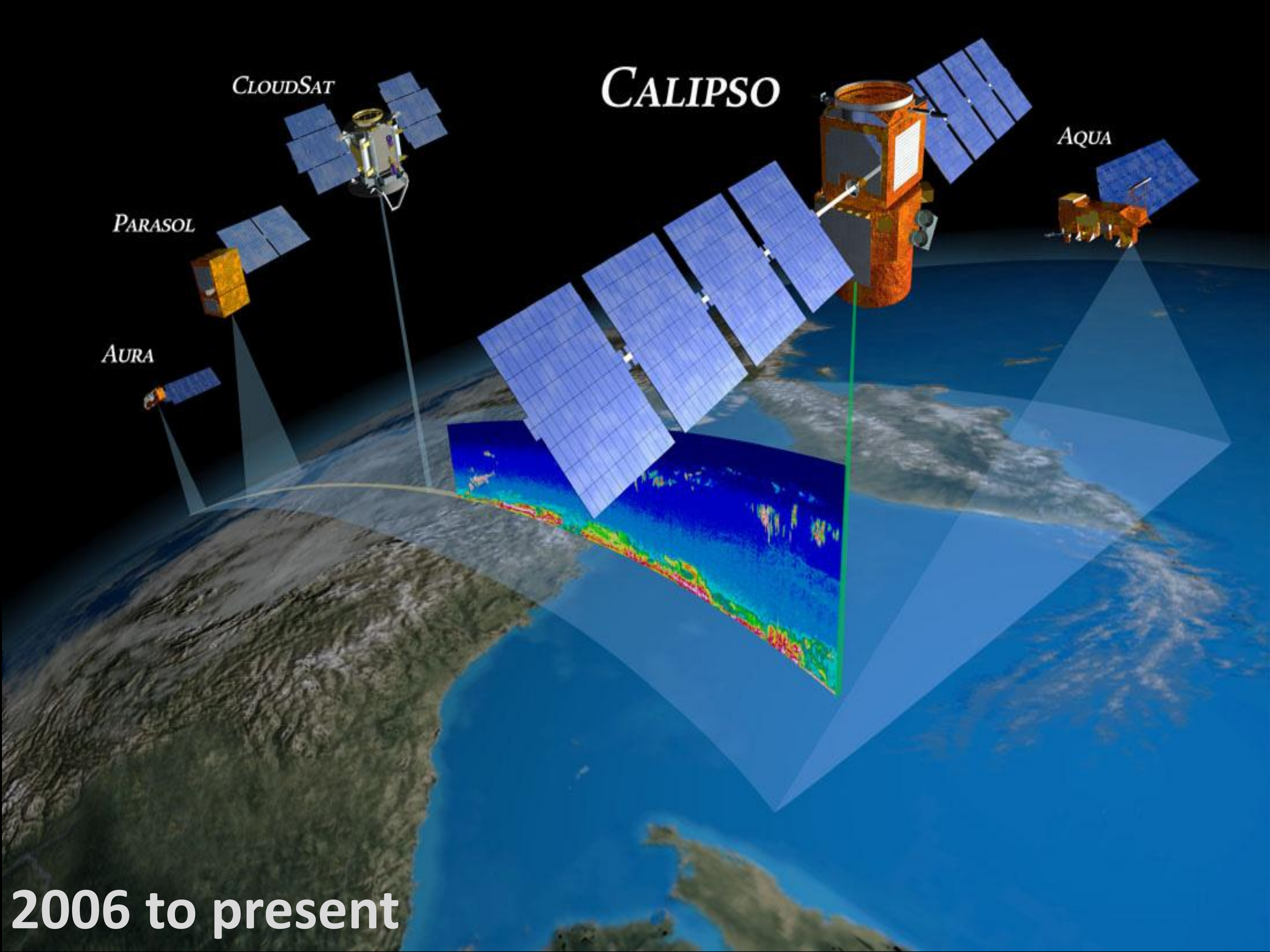


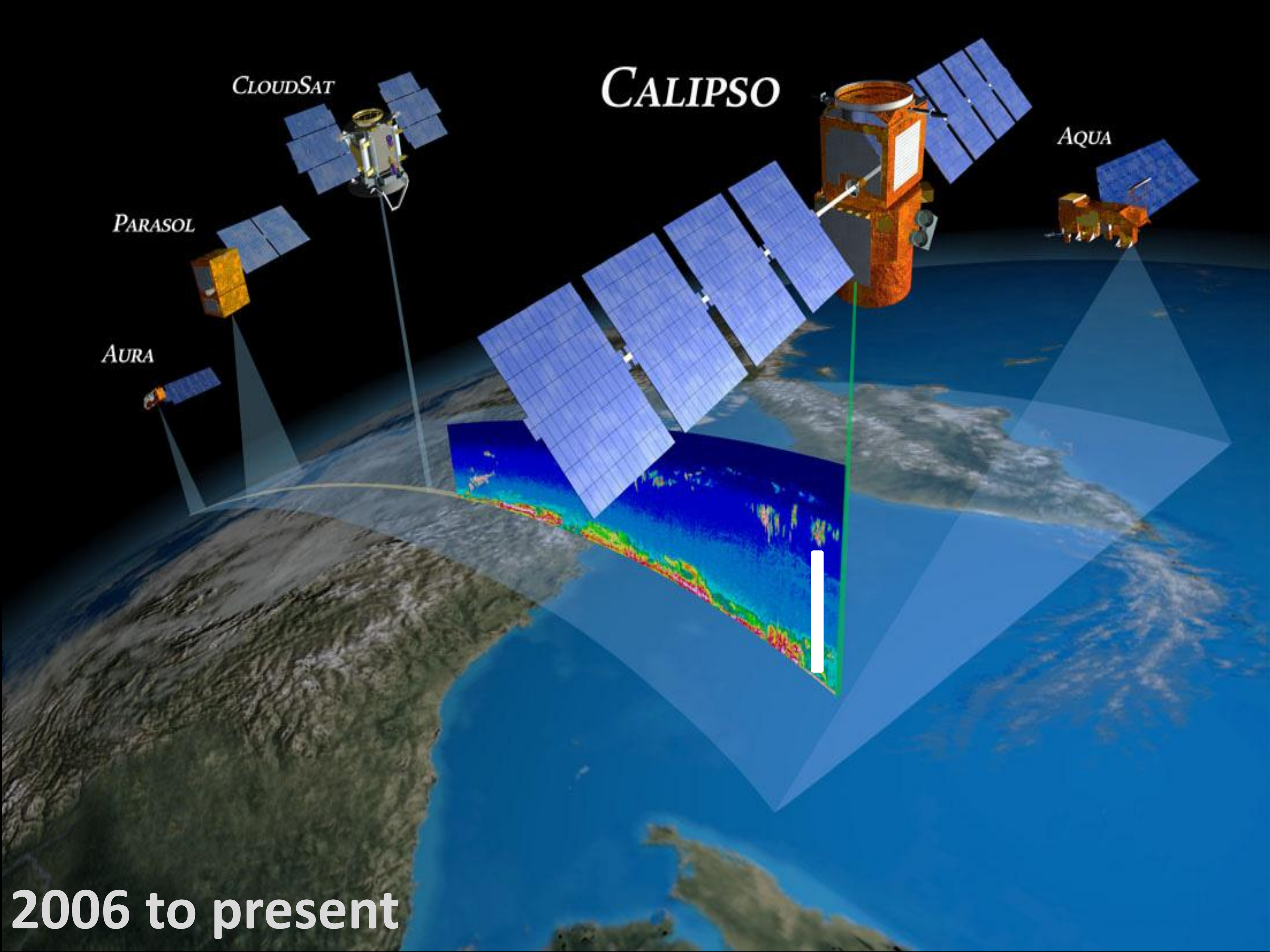
Stramler et al. (2011)

SHEBA Winter Atmospheric Temperature and Humidity Structure

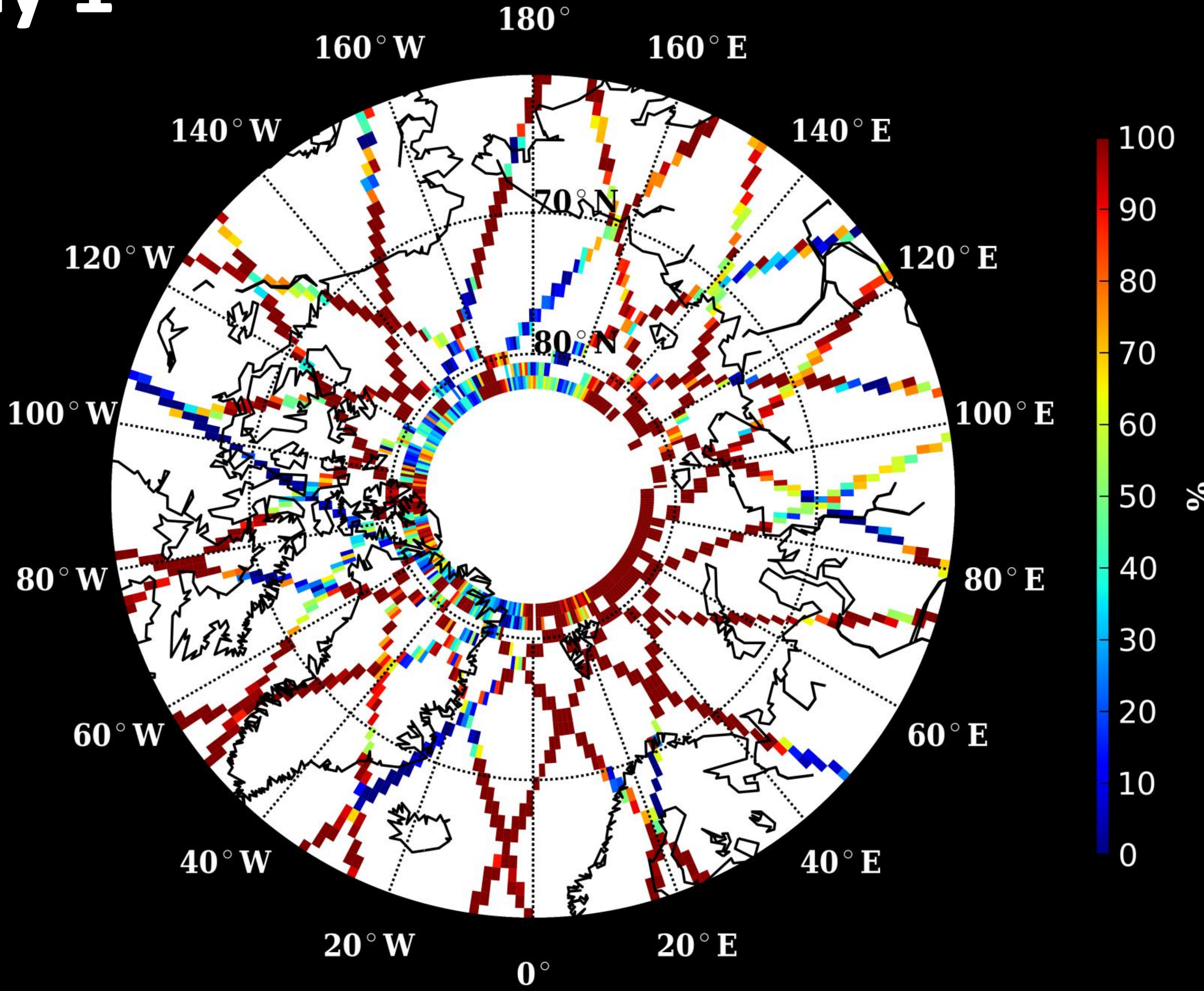


Stramler et al. (2011)


CloudSat
Calipso
Aqua
Parasol
Aura
2006 to present

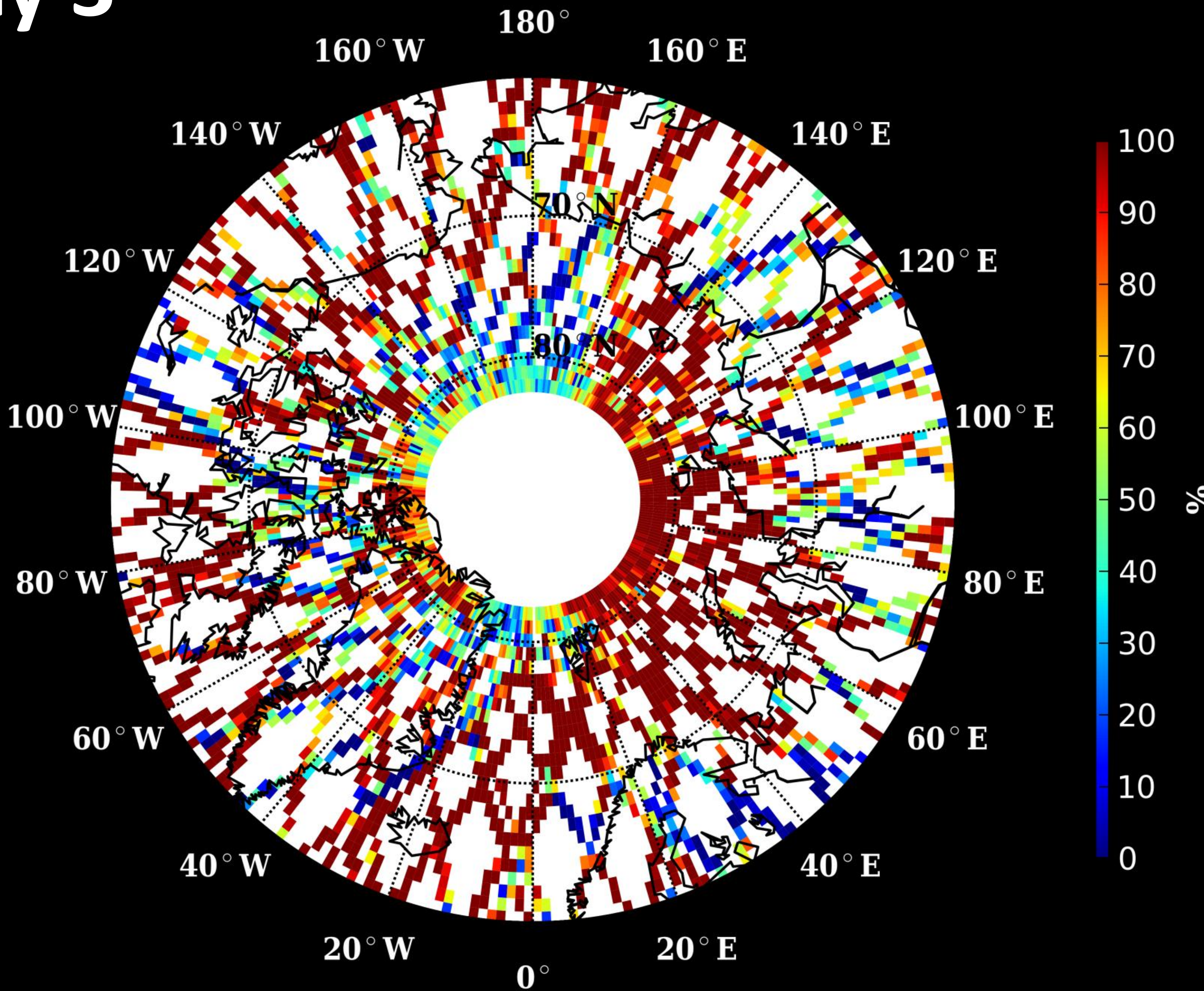

CloudSat
Calipso
Aqua
Parasol
Aura
2006 to present

Day 1



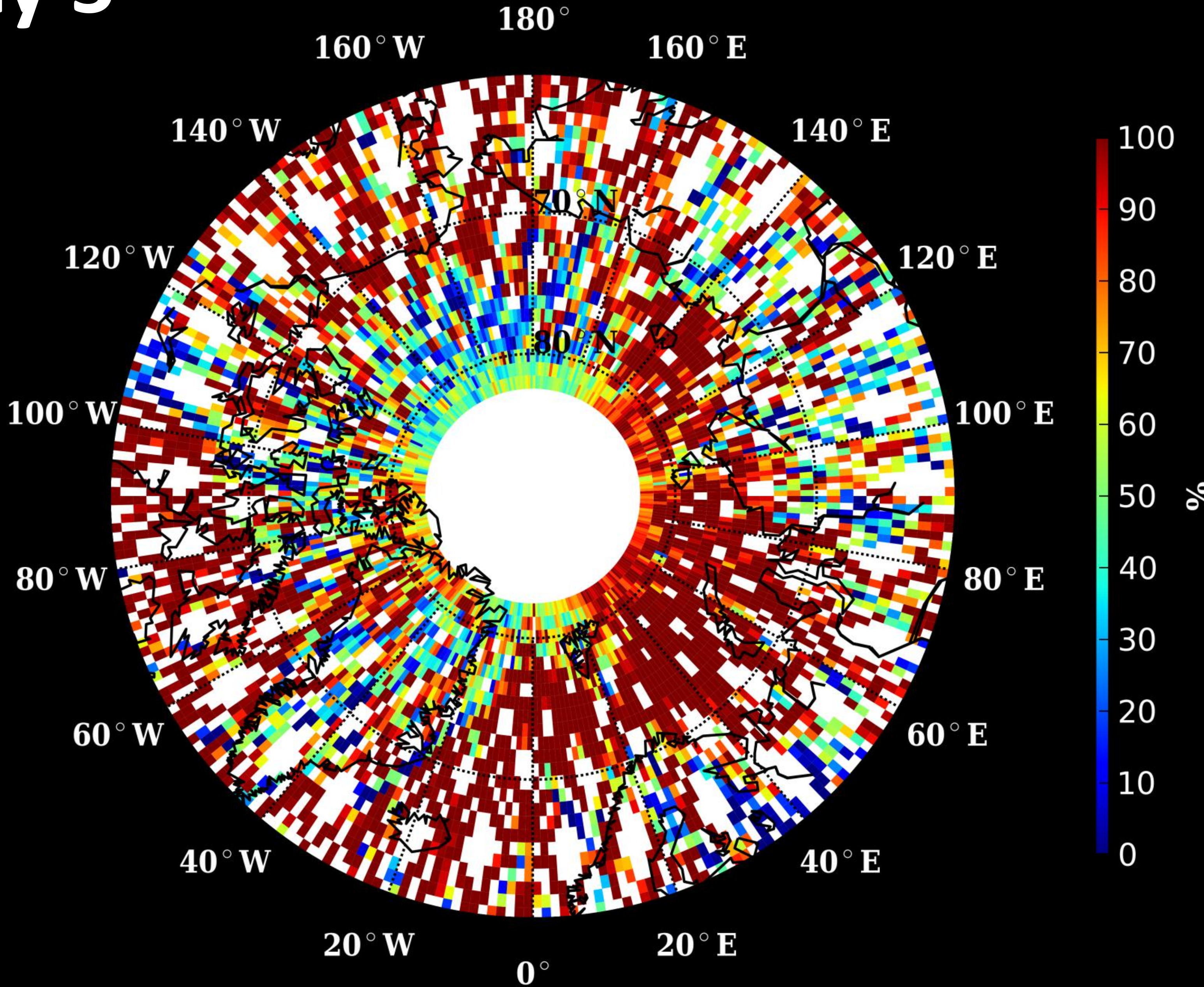
1.25 lon° by 0.94 lat° grid

Day 3



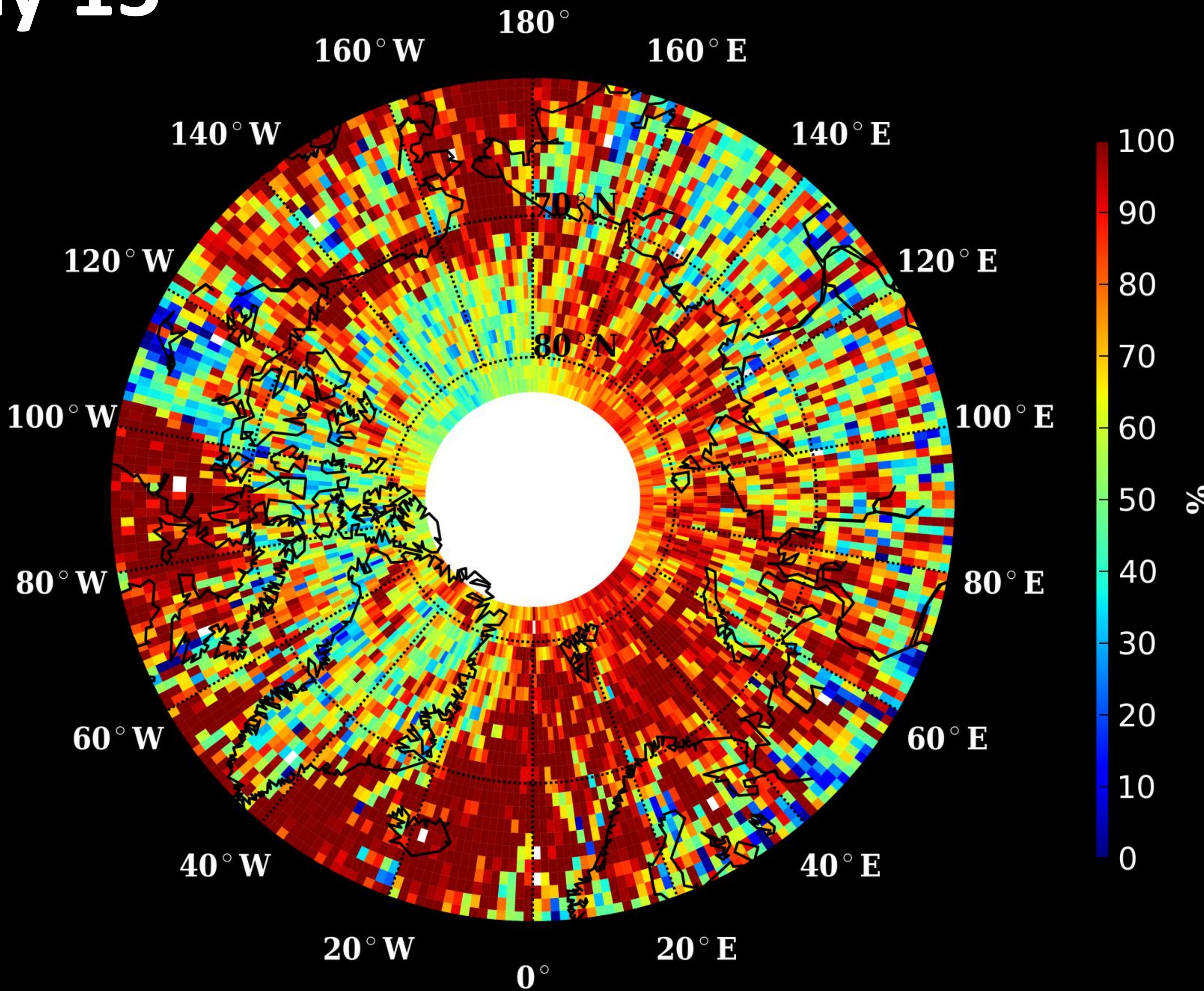
1.25 lon° by 0.94 lat° grid

Day 5

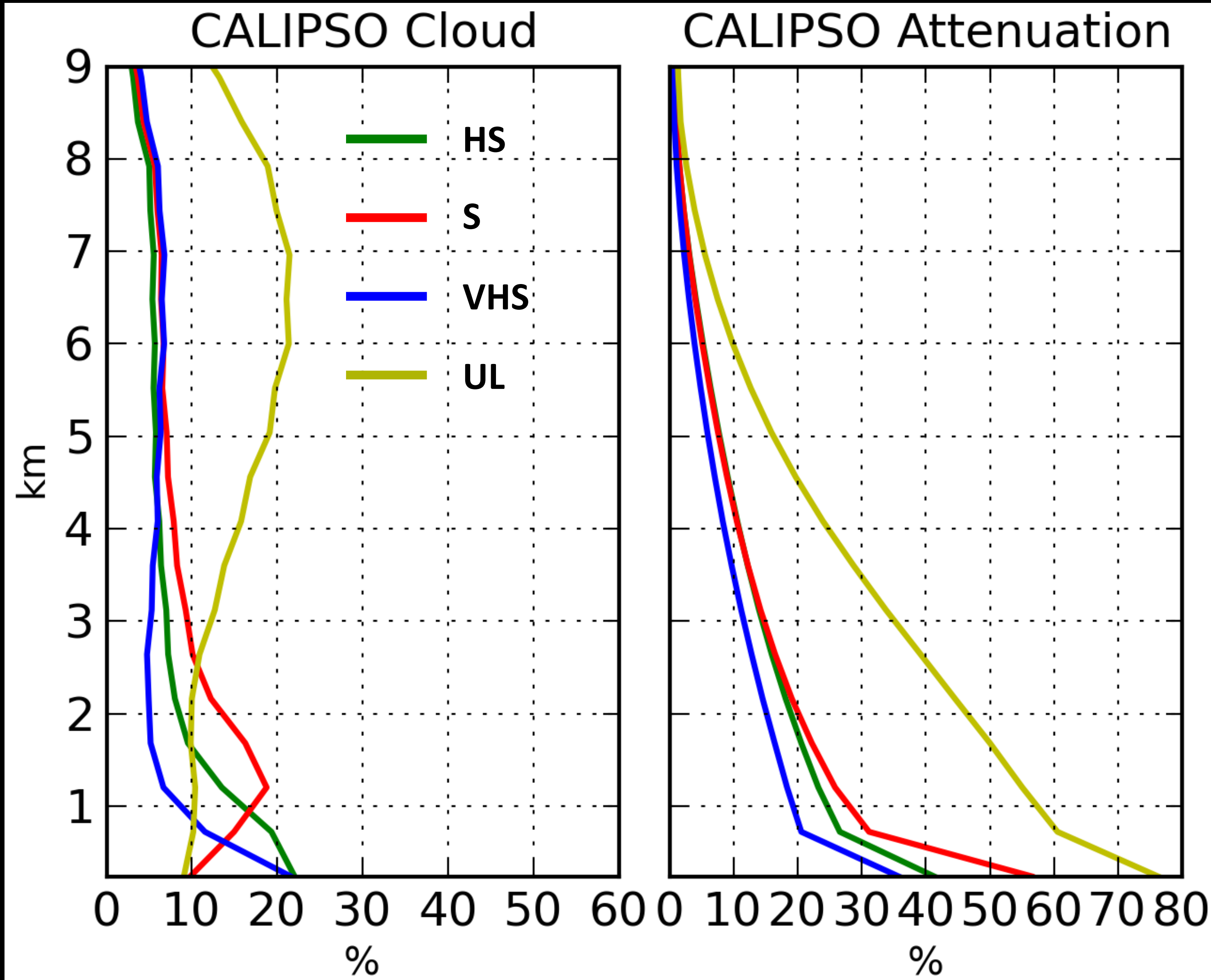


1.25 lon° by 0.94 lat° grid

Day 15

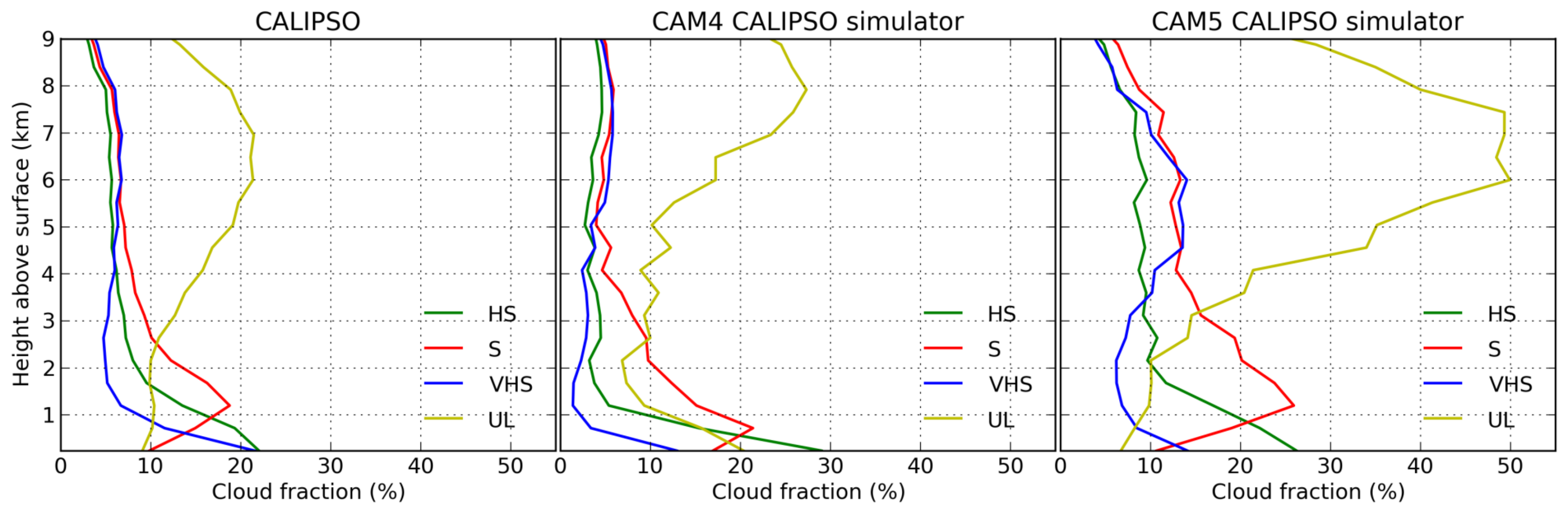


1.25 lon° by 0.94 lat° grid



HS = Highly Stable Lower Troposphere; S = Stable lower Troposphere;
VHS = Very Highly Stable Lower Troposphere; UL = Mid-Tropospheric Uplift

Barton et al. (in press)



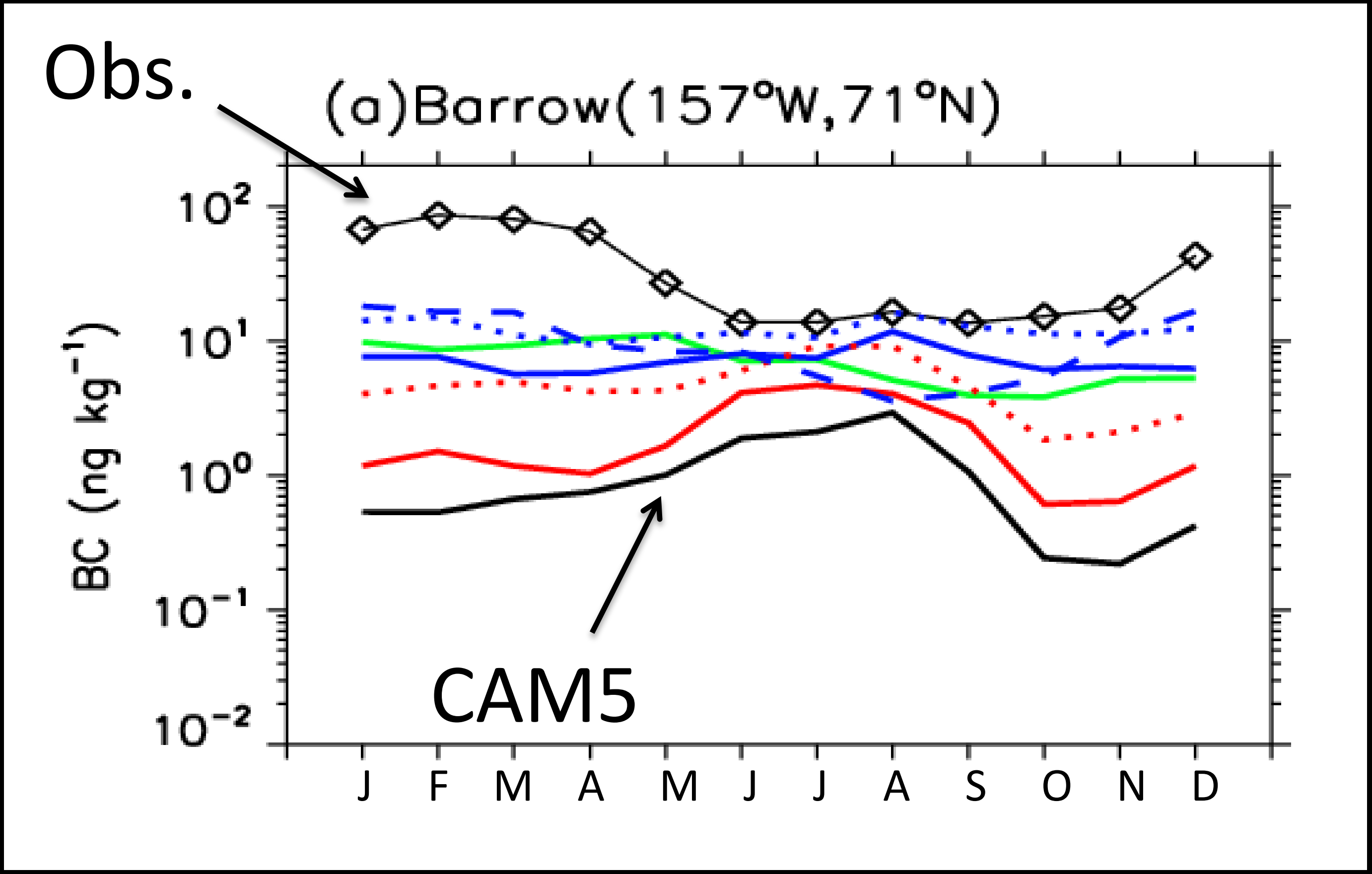
HS = Highly Stable Lower Troposphere; S = Stable lower Troposphere;
VHS = Very Highly Stable Lower Troposphere; UL = Mid-Tropospheric Uplift

Barton et al. (in press)

Possible Research Directions

- Model Improvements to Reduce
  - Uncertainty in the fluxes associated with radiative forcing
  - Spread in climate projections

Aerosols



Wang et al. (2012)

Reducing Uncertainty in Climate Projections

Current GCMs' Unrealistic Negative Feedback in the Arctic

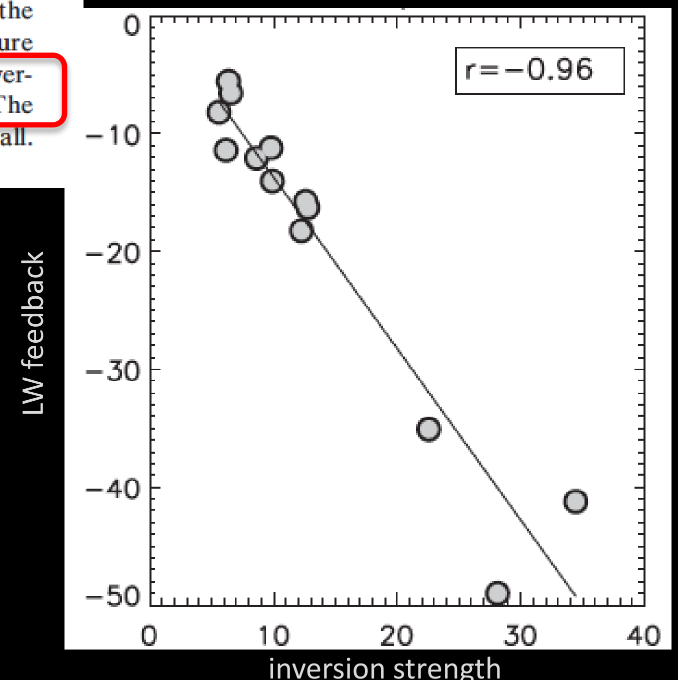
JULIEN BOÉ, ALEX HALL, AND XIN QU

Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, California

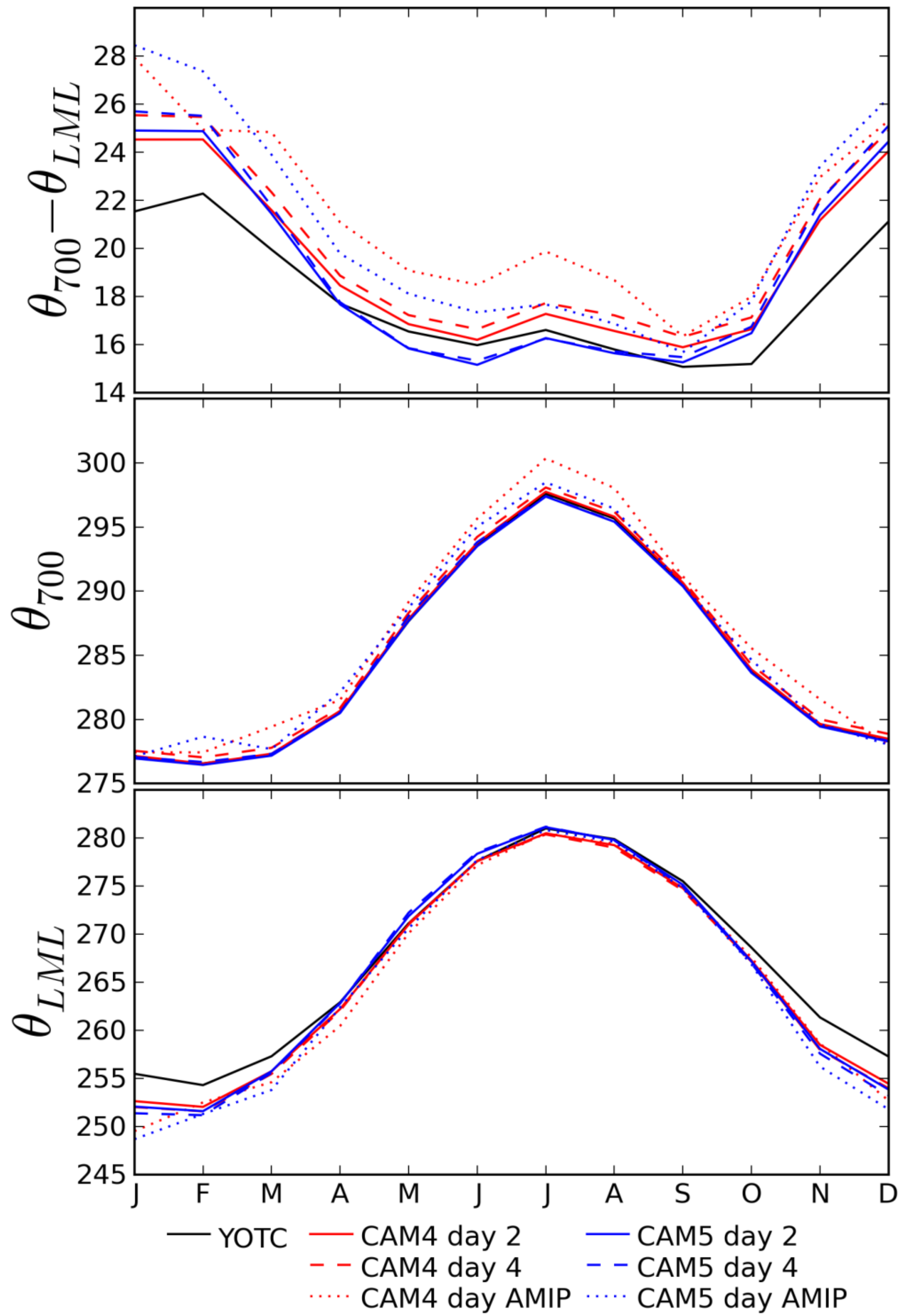
(Manuscript received 7 October 2008, in final form 13 March 2009)

ABSTRACT

The large spread of the response to anthropogenic forcing simulated by state-of-the-art climate models in the Arctic is investigated. A feedback analysis framework specific to the Arctic is developed to address this issue. The feedback analysis shows that a large part of the spread of Arctic climate change is explained by the longwave feedback parameter. The large spread of the negative longwave feedback parameter is in turn mainly due to variations in temperature feedback. The vertical temperature structure of the atmosphere in the Arctic, characterized by a surface inversion during wintertime, exerts a strong control on the temperature feedback and consequently on simulated Arctic climate change. Most current climate models likely over-estimate the climatological strength of the inversion, leading to excessive negative longwave feedback. The authors conclude that the models' near-equilibrium response to anthropogenic forcing is generally too small.



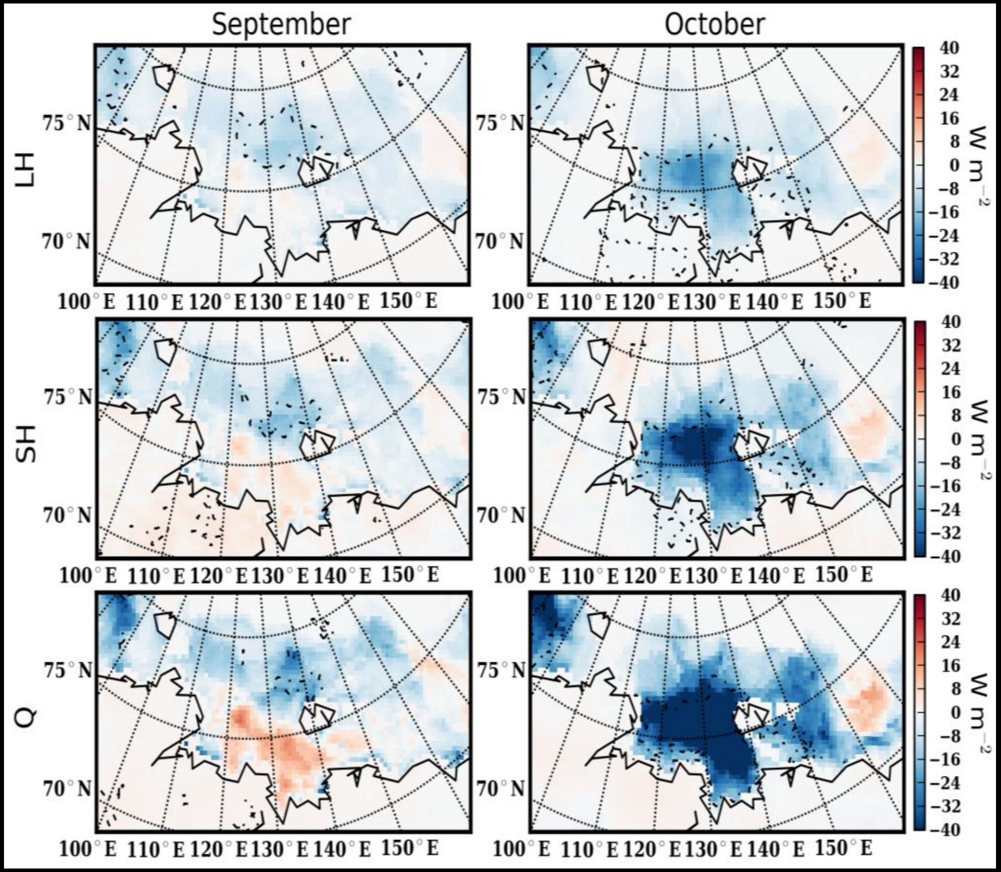
Boe et al. (2009)



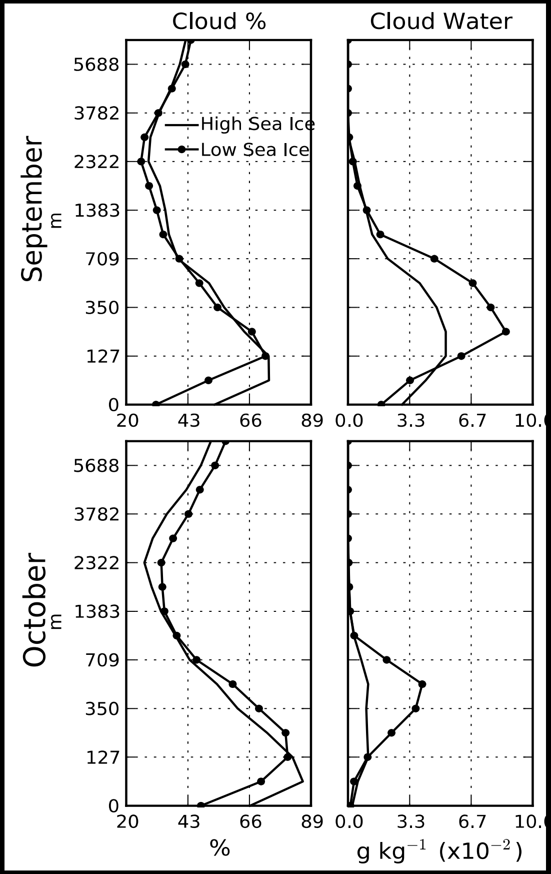
$\theta_{700} - \theta_{LML}$
θ_{700}
θ_{LML}
J F M A M J J A S O N D
YOTC
CAM4 day 2
CAM4 day 4
CAM4 day AMIP
CAM5 day 2
CAM5 day 4
CAM5 day AMIP

Observations Needed to Improve Climate Models

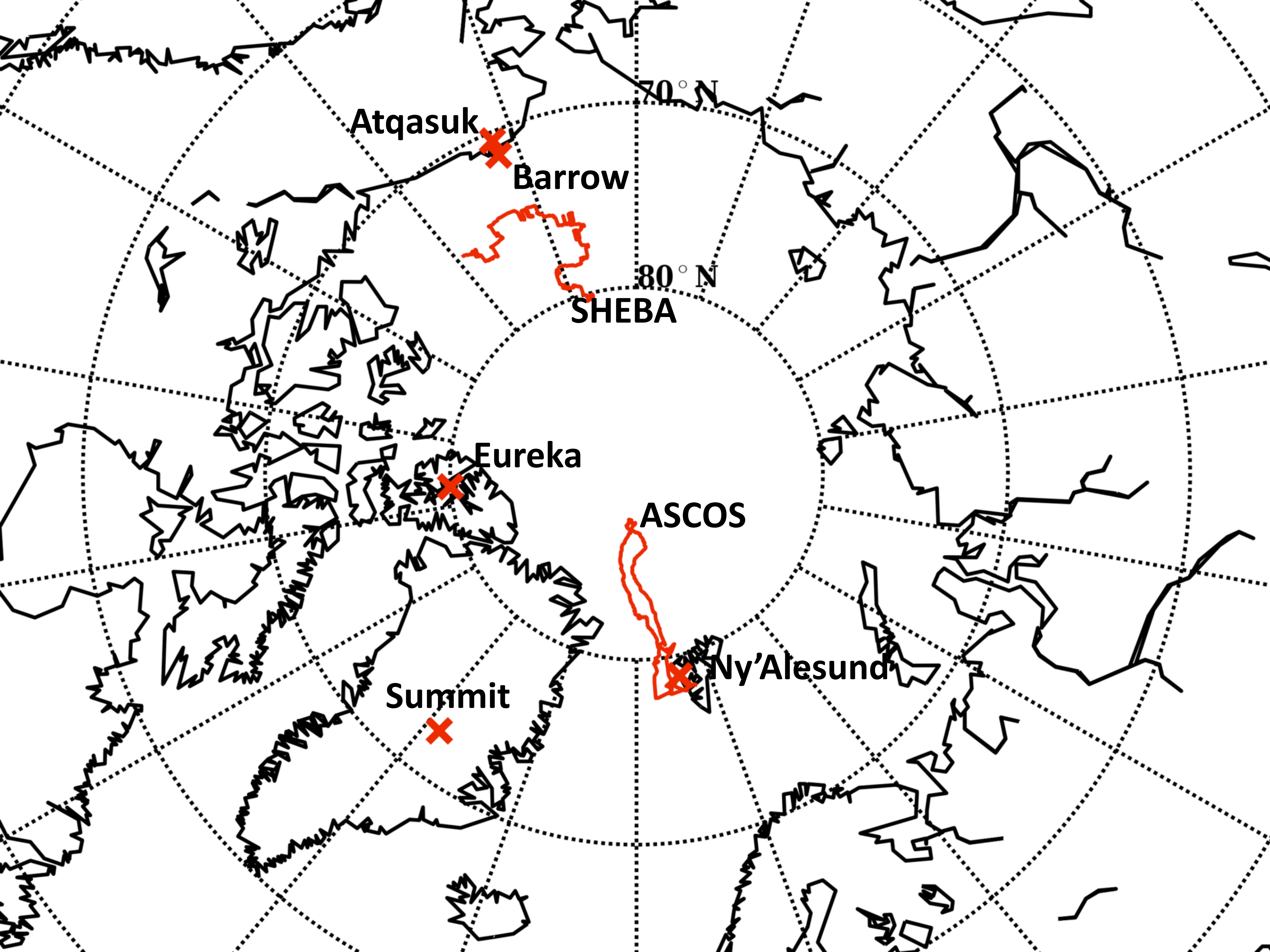
Energy Fluxes over open water compared to Energy Fluxes over sea ice



High Minus Low Sea Ice Years

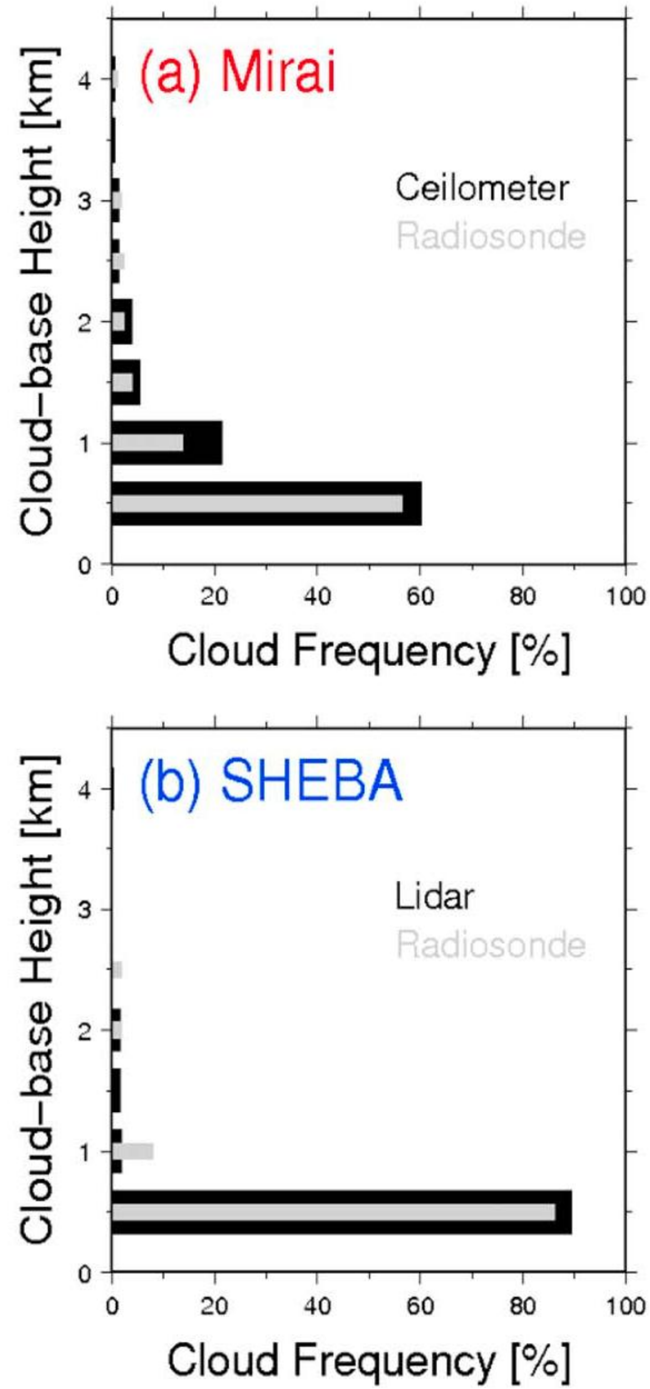


Barton and Veron (in press)

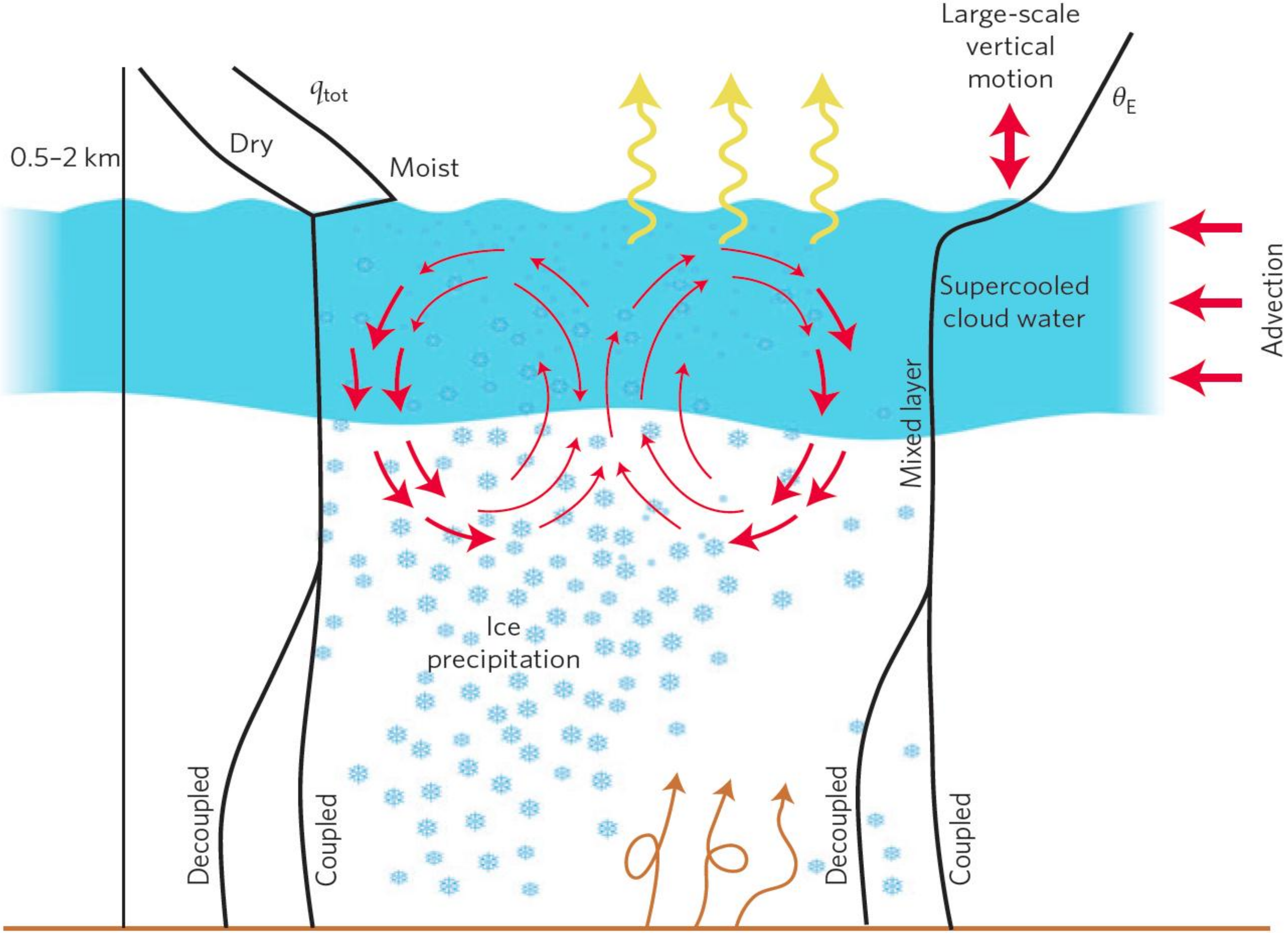

70° N
80° N
Atqasuk
Barrow
SHEBA
Eureka
ASCOS
Ny'Alesund
Summit

Open Water

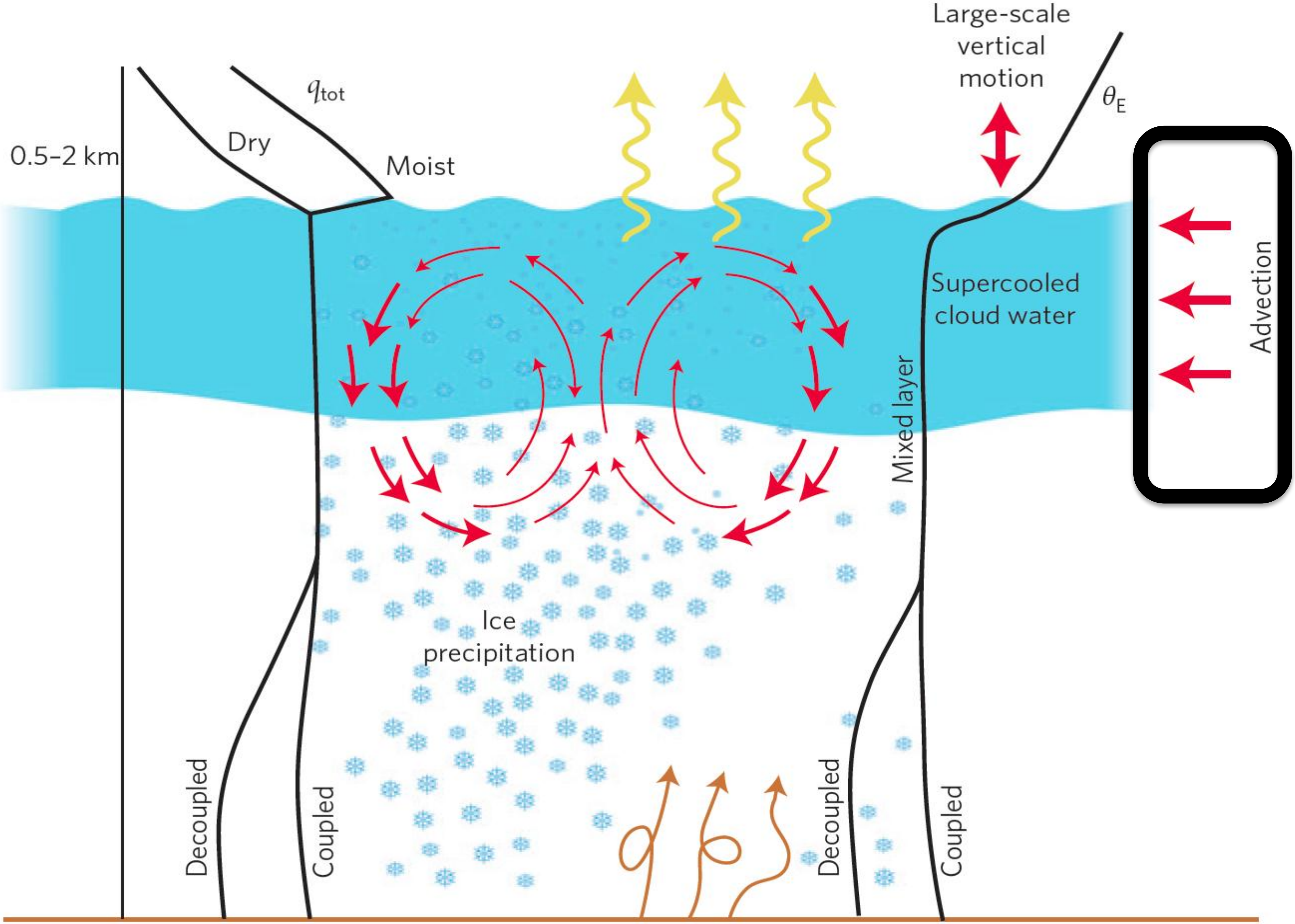
Sea Ice



Sato et al. (2012)



Morison et al. (2011)



Morison et al. (2011)

On the Relationship between Thermodynamic Structure and Cloud Top, and Its Climate Significance in the Arctic

JOSEPH SEDLAR

Remote Sensing Division, Research Department, Swedish Meteorological and Hydrological Institute, Norrköping, Sweden

MATTHEW D. SHUPE

Cooperative Institute for Research in Environmental Sciences, University of Colorado, and NOAA/ESRL/PSD, Boulder, Colorado

MICHAEL TJERNSTRÖM

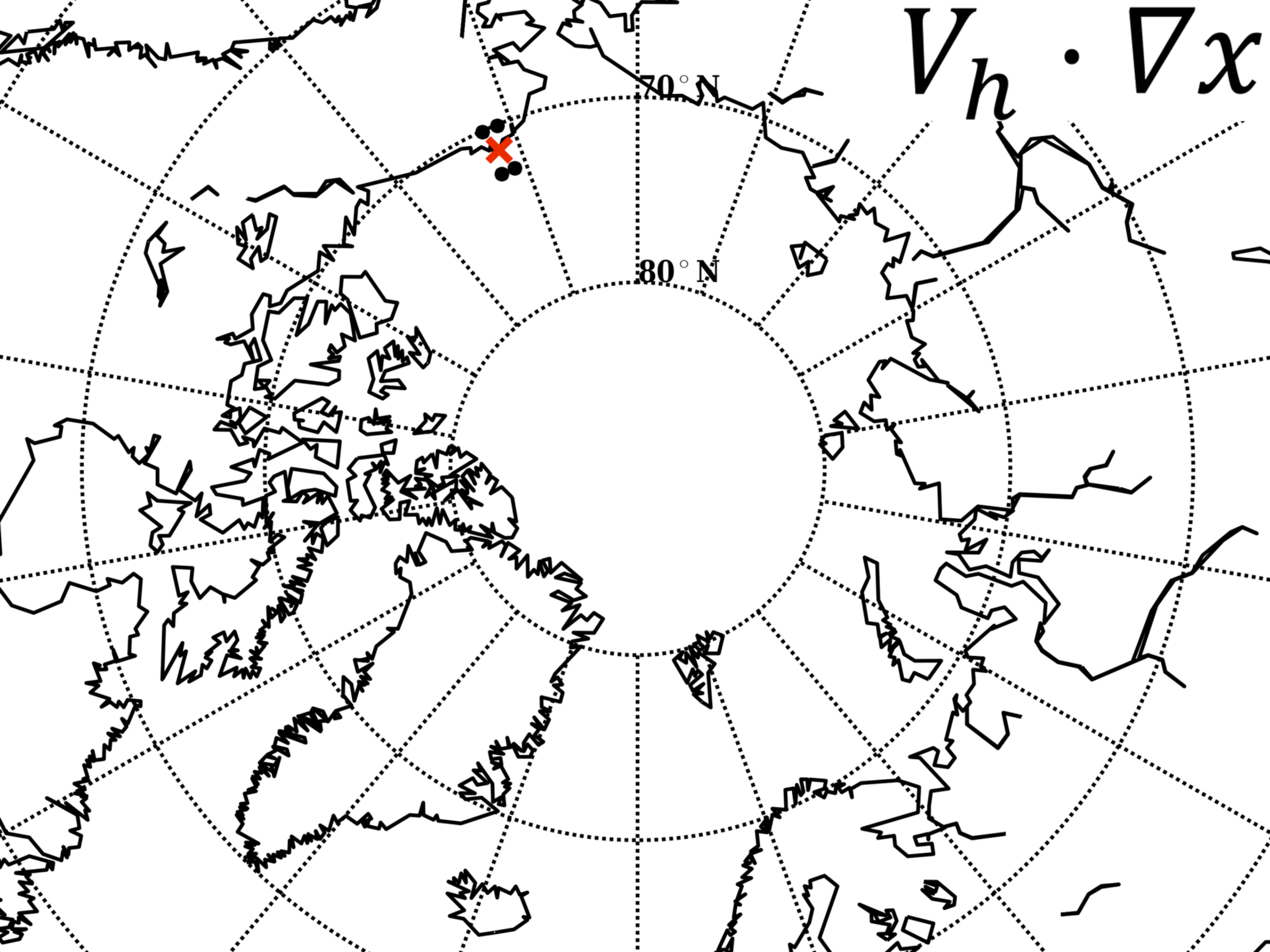
Department of Meteorology, Stockholm University, and Bert Bolin Centre for Climate Research, Stockholm, Sweden

(Manuscript received 4 April 2011, in final form 18 August 2011)

ABSTRACT

Cloud and thermodynamic characteristics from three Arctic observation sites are investigated to understand the collocation between low-level clouds and temperature inversions. A regime where cloud top was 100–200 m above the inversion base [cloud inside inversion (CII)] was frequently observed at central Arctic Ocean sites, while observations from Barrow, Alaska, indicate that cloud tops were more frequently constrained to inversion base height [cloud capped by inversion (CCI)]. Cloud base and top heights were lower, and temperature inversions were also stronger and deeper, during CII cases. Both cloud regimes were often decoupled from the surface except for CCI over Barrow. In-cloud lapse rates differ and suggest increased cloud-mixing potential for CII cases.

Specific humidity inversions were collocated with temperature inversions for more than 60% of the CCI and more than 85% of the CII regimes. Horizontal advection of heat and moisture is hypothesized as an important process controlling thermodynamic structure and efficiency of cloud-generated motions. The portion of CII clouds above the inversion contains cloud radar signatures consistent with cloud droplets. The authors test the longwave radiative impact of cloud liquid above the inversion through hypothetical liquid water distributions. Optically thin CII clouds alter the effective cloud emission temperature and can lead to an increase in surface flux on the order of 1.5 W m^{-2} relative to the same cloud but whose top does not extend above the inversion base. The top of atmosphere impact is even larger, increasing outgoing longwave radiation up to 10 W m^{-2}. These results suggest a potentially significant longwave radiative forcing via simple liquid redistributions for a distinctly dominant cloud regime over sea ice.



$V_h \cdot \nabla x$
70° N
80° N

Discussion Points

- Model Improvements
  - Uncertainty in energy fluxes
    - Aerosols (transport, direct, and indirect effects)
    - Tighter coupling between the component models' radiation code
  - Climate Projections
    - Examine areas where the modeled mean state relates to differences in climate projections
    - Correct any biases in the mean state
- Observations Needed
  - Aerosols, energy fluxes and cloud profiles over open water, advection, precipitation